TECHNICAL
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NATIONAL PHOTOGRAPHIC
INTERPRETATION CENTER

TEST AND EVALUATION REPORT

25X1

GLIDE STAGES AND PLATENS
FOR THE HIGH POWER STEREOVIEWER

CONFIDENTIAL

NPIC/R-15/73
JULY 1973

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Comments and queries regarding this report are welcomed.

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ABSTRACT

The 120X Capability for the Zoom 240 System consists of 15X eyepieces and 2.65X mono and stereo objectives. These prototype components were made by [redacted] to NPIC specifications. Two types of eyepieces are required by the contract: the first is designed to fit Zoom 240's with small image rotation prisms; the second (to be delivered in August 1973) is designed to fit all Zoom 240's. 25X1

Acceptance, engineering, and operational suitability testing were performed from January to May 1973. Most of the design goals were met by the prototype components. On-axis resolution with the 2.65X stereo objectives is 456 line pairs/mm, and with the mono objective the resolution is 512 line pairs/mm. Visual transmission of the stereo optics at 120X is 1.3 percent. Normal optics at 60X have a visual transmission of 3.1 percent.

Most users found the 120X magnification to be sufficiently high. However, vibration of the light tables is considered to be a serious problem. The larger field of view of the 15X eyepieces was well received.

1. INTRODUCTION

The 120X capability is provided by 15X (nominal) eyepieces and 2.65X (nominal) objectives on a Zoom 240 which itself has a 3X magnification capability. Two sets of 15X eyepieces are required by the contract: the first set will fit the newest version of the Zoom 240, which has smaller image rotation prisms and the second set will fit any Zoom 240 with large or small image rotation prisms or even no prisms at all. The first set of 15X eyepieces was received at NPIC on 14 December 1972. Preacceptance testing of these eyepieces was accomplished before delivery on 13 December 1972 and was reported in memorandum TEB-083/72, dated 20 December 1972. The 2.65X stereo objectives were received at NPIC on 22 January 1973. Acceptance testing of the 2.65X stereo objectives with 15X eyepieces was completed on 7 February 1973. Acceptance testing of the 2.65X monoscopic objective was completed on 15 February 1973. The operational evaluation was completed on 14 May 1973, and the engineering evaluation tests were concluded on 30 May 1973.

This report contains acceptance test results, certain human-factor engineering evaluation results, and a summary of operational evaluation reports from two operating components
25X1 in [redacted] TEB plans similar testing when the second set of 15X eyepieces arrive; these eyepieces are scheduled to be delivered in August 1973.

2. SUMMARY

2.1 Acceptance Tests

The requirement for high power system magnification of 120X was satisfied. The magnification of the eyepieces measured an acceptable 15.8X.

Eye relief measured 20 mm exactly as required.

On-axis resolution with the stereo objectives was 456 1/mm or 75 percent of the design goal. With the mono objective the resolution at 120X was 512 1/mm or 84 percent of the design goal.

Field of view at the eyepiece focal plane measured 19.6 mm as required.

Optical distortion of the 120X system was measured to be within the 7 percent maximum over 77 to 80 percent of the respective stereo and mono fields of view.

Working distance with the stereo objective is 5.9 mm. This is much better than the 1.5 mm goal.

The requirement that the system be designed such that no modules have to be removed when switching from mono to stereo or vice versa was not met.

Image quality of the 120X stereo capability was comparable to the standard Zoom 240 system as required. In the monoscopic mode, image quality was degraded in the sense that the tipped field phenomenon is more severely manifested at higher magnification with shallower depth of focus.

2.2 Engineering Evaluation

Visual transmission of the stereo system at 120X is 1.3 percent. The standard components have a transmission of 3.1 percent at 60X magnification.

The 5.9 mm working distance of the stereo objectives is less than the thickness of the commonly used green plastic holddown rings and prohibits their use.

The theoretical depth of field of the 120X stereo system is 28 micrometers. This value relates favorably with an observed loss of two AF resolution target elements at the extreme ends of a 42 micrometer focus range.

The focus mechanism originally provided on the AIL 1540 light table is a limiting factor in the use of 120X capability due to the small depth of field. However, performance of the focus mechanism is judged to be satisfactory on tables which have been modified by changing the focus mechanism gear ratio.

2.3 Operational Suitability Evaluation

Most users considered image vibration to be a serious problem when using the high magnification provided by these optics.

Twenty-five PI's unanimously reported that the 120X magnification was sufficient. With this increased magnification of the 240 system, the need for chipping films should decrease.

Illumination through the optics seems adequate. However, not enough light passes through the viewing ports of the stereo objectives. Several users believed that stereo fusion could be achieved faster without using the viewing ports.

One operating component commented that the large diameter eyepieces were bothersome since they pressed against the user's nose.

3. CONCLUSIONS AND RECOMMENDATIONS

The 120X Capability for the Zoom 240 essentially met contractual objectives and specifications.

In general, the 120X capability was accepted as being useful. However, engineering and operational evaluation uncovered several problems.

TEB concluded, in agreement with the operating components, that the 120X capability will be severely limited by vibrations. If the 120X capability is procured in quantity, TEB recommends that the light table vibration problems be pursued vigorously.

The low illumination and parallax problems associated with the viewing ports make the value of this feature questionable. A separate T&E report, NPIC/R-13/73, covers the viewing port feature in detail.

Use of the mono objective is seriously hampered by the need to remove the 2.65X stereo objectives. With this handicap and from the comments received from the operating components, the value of this feature is also questionable.

TEB also recommends that the focus mechanism of the AIL light tables, as originally provided, be improved before providing the PIs with the 120X capability.

4. DESCRIPTION OF EQUIPMENT

The 120X capability consists of a set of 15X prototype eyepieces that will fit the newer Zoom 240 microstereoscopes (image rotation version with 55 mm minimum IPD), a set of 2.65X prototype objectives for stereoscopic viewing on the Zoom 240 stereoscope system, and a prototype 2.65X monoscopic objective. The zoom system of the Zoom 240 goes up to 3X, which together with the eyepieces and objectives provides the 120X (nominal) magnification.

The eyepieces are physically large (40.45 mm diameter) as is evident in Figure 1. A closeup view of the objectives is shown in Figure 2. Visible is the quarter-turn locking flange that joins the stereo objective to the rhomboid arm. The monoscopic objective has a large diameter thread for mounting.

The stereo objectives have viewing ports for straight-through viewing of the imagery under the objectives. Each stereo objective has a white dot on the viewing port window for alignment purposes. One of the two objectives has a second white dot on the beam splitter to aid the PI in aligning the imagery with the field of the 120X system.

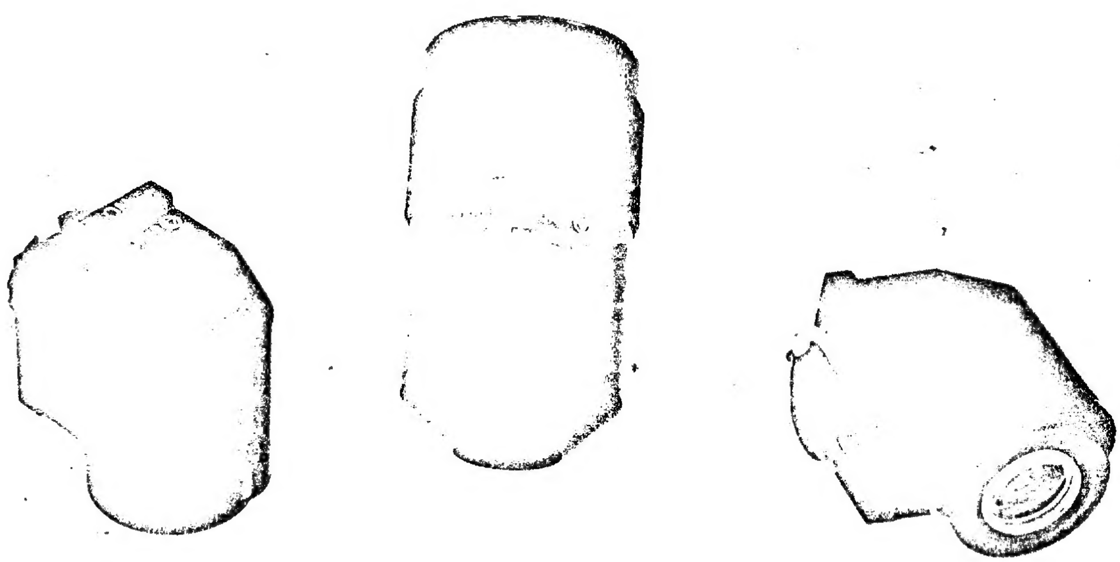

Figure 2. Monoscopic (Center) and Stereoscopic 2.65X (Nominal) Objectives

5. TEST DETAILS

5.1 Acceptance Tests

Optical Magnification

The design goal for the system magnification at high power is 120X. The eyepieces shall have a minimum magnification of 15X.

Test Method - The first test is to measure the maximum total system magnification (linear). Mount a diopter telescope on an angle measuring table so that their axes intersect at 90 degrees. Place the axis of rotation of the table so that it intersects the optical axis of the eyepiece and lies in the plane of its exit pupil. Measure the angle subtended by the diopter telescope positions when viewing the ends of a known or measurable distance in the object plane. Set the eyepiece and rhomboid focal adjustments at their midpoints (see Section 5.2) and record the IPD setting.

The second test is to determine the angular magnification of the eyepieces. Use the TEB Centering Eyepiece with reticle and a scale at the film plane to measure the linear magnification of the objectives. Divide the previously determined total system magnification by the linear magnification of the objective and zoom to obtain the angular magnification of the eyepiece.*

Test Results - IPD setting minimum.

	Mono	Side Left	Side Right
Object plane distance	1.00 mm	0.1 mm	0.1 mm
Angle subtended	26.95°	2.7°	2.7°
Linear magnification	122X	120X	120X

* Jenkins & White Fundamentals of Optics, 3rd. ed. (p. 177)

	Objective* 1 Dot	Objective* 2 Dot
Eyepiece scale	7.60 mm	7.55 mm
Film plane scale	1.00 mm	1.00 mm
Magnification (linear)	7.60X	7.55X
Total magnification	120X	120X
Eyepiece magnification (angular)	15.8X	15.9X

Conclusions - These requirements are satisfied.

Eye Relief

The eyepieces shall have a minimum eye relief of 20 mm.

Test Method - Place a viewing screen above the eyepiece such that the smallest, sharpest spot of light is visible. Measure the screen's height above the highest part of the eyepiece.

Conclusion - The eyepieces meet this requirement.

Field of View

The design goal for the eyepiece focal plane diameter is 19.6 mm.

Test Method - Focus the Zoom 240 microstereoscope system with the 2.65X objectives and 15X eyepieces on a grid. Remove an eyepiece and position a viewing screen at the eyepiece focal plane. Note how many grid squares lie within 19.6 mm on the viewing screen. Replace the eyepiece and note whether or not the same number of grid squares are visible.

Conclusion - This goal is satisfied.

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* The stereo objectives have no serial numbers to identify them, but one has a single alignment dot in its viewing port and the other has two dots for alignment.

Optical Resolution

The design goal is 609 line pairs/millimeter.

Test Method - Focus the system at 120X magnification on a high contrast USAF Tribar resolution target in the center of the field of view. Record the smallest target element in each case that meet the following criteria:

1) A space visible between and along the length of each pair of adjacent bars.

2) The three bars can be counted.

Test Results - The smallest resolvable target (TEB #28) element was 8,6 (456 line pairs/mm) with the stereo objectives. The resolution was 9,1 (512 line pairs/mm) with the monoscopic objective, however, refocusing was required for off-axis readings.

Conclusion - The eyepieces and stereo objectives are within 25 percent of this design goal. And with the monoscopic objective, are within 16 percent of the goal.

Optical Distortion

The design goal is a maximum of 7 percent.

Test Method - Use the test method for measuring magnification, both on axis and near the edge of the field of view. Calculate the difference in percent.

Test Results - With stereo objectives the maximum distortion is 7-1/2 percent plus or minus 4 percent, due to uncertainty of measuring system. Measurements were made out to 77 percent of the field of view. The monoscopic objective cannot be focused on both the left and right sides of the field of view simultaneously at 120X. With refocusing, the distortion is less than 7 percent out to 80 percent of the field of view.

Conclusion - This design goal is met over the central 77 percent of the field-of-view (FOV) diameter with the stereo objectives. The monoscopic objective meets this design goal out to about 80 percent of the field of view.

Working Distance

The design goal is 1.5 mm.

Conclusion - The 5.9 mm working distance for the stereo objectives and 3.4 mm for the mono greatly exceeds the design goal (see the fifth paragraph in Section 5.2).

Parfocality

It is a design goal that the system be designed such that the operator does not have to remove any modules when switching from mono to stereo or vice versa. Refocusing may be necessary.

Test Method - Mount the 15X eyepieces and 2.65X objectives on a Zoom 240 stereoscope system. Determine whether the Zoom 240 can be switched back and forth between the mono and stereo viewing modes.

Test Result - There is up to 0.66 mm interference between the stereo objectives and the surface of the light table when the mono objective is focused.

Conclusion - This design goal is not met.

Image Quality

It is a design goal that there be no noticeable degradation of image quality when switching from 10X WF eyepieces and 2X objectives to the proposed 120X viewing system on a Zoom 240 (53-70-25).

Test Method - Focus on a grid target that fills the field of view. Use a slow scan motion and notice the development of curvature in the grid lines as they traverse the field of view. Examine the image for other image degradation.

Test Result - The only noticeable image degradation in the stereo objectives was the barrel distortion near the edges of the field of view. The standard 10X eyepiece and 2X stereo objective system had a barely detectable amount of the opposite kind of distortion (pincushion).

The standard 10X eyepieces with 2X monoscopic objective can be focused on lines 3 mm apart on the light table. However, with the 15X eyepieces and 2.65X monoscopic objective, lines 2 mm apart not only cannot be focused simultaneously for a given eye, but when refocusing (with the scope carriage control) from the center of the field of view to the left or right line, the focus for one eye always gets worse as the other gets better.

Conclusion - The stereo objectives with the 15X eyepieces meet the requirement; only one PI out of 25 in the operational evaluation even commented on any distortion. That PI's component reported that the distortion was no worse than the standard Zoom 240 system.

In the monoscopic viewing mode, the image is degraded, therefore, the design goal is not met for the mono case.

Eyepiece Interchangeability

It is a design goal that the 15X eyepieces be interchangeable with standard 10X eyepieces on the Zoom 240 pod (53-70-25).

Conclusion - This design goal is met.

5.2 Engineering Evaluation

System Magnification

The magnification can be changed up to 4 percent on the left side by focusing the left eyepiece tube of the Zoom 240 all the way down. It can be changed up to 6 percent on either side by changing the rhomboid arm focus from one extreme to the other. Note that refocusing is accomplished with the microscope carriage control in each case.

Viewfinder Dots

The 2.65X stereo objective with two alignment dots in its viewing port was found to point to a spot 0.3 mm outside the

field of view at 120X. If properly aligned, the concept of two alignment dots to eliminate parallax would probably be satisfactory. The viewing port feature has previously been evaluated in detail in T&E Report NPIC/R-13/73.

Light Transmission

The visual transmission in the stereo mode was measured to be 1.2 percent and 1.3 percent at 120X. The standard 10X eyepiece and 2X stereo objective yielded a visual transmission of 3.1 percent at 60X. In the mono mode the transmission was 3.4 percent at 120X. And the standard 10X eyepieces with the 2X objective had a transmission of 6.9 percent at 60X.

Depth of Field

The theoretical depth of field at 120X was calculated to be 28 micrometers, which supposedly is the threshhold (zero) loss in resolution range (25 micrometers = 0.001 inch). This value is not in conflict with the following measured results which were obtained by using a very precise micrometer head to position an Air Force resolution target in the object plane. It was determined by averaging an appropriate number of readings that a loss of two target elements occurs at the extreme ends of a 42 micrometer focus range and a loss of four elements at the ends of a 78 micrometer focus range.

Human-Factor Comments

To lock a stereo objective to a rhomboid arm, it is necessary to turn it about 30 degrees about an axis parallel to the surface of the light table. It happens that if a 2X objective has been in focus and the 2.65X objective is installed without raising the microscope carriage, part of the lower surface of the latter will strike the table (or film). This is because the 2.65X stereo objectives extend further toward the light table surface than do the 2X stereo objectives.

It should be noted that the 2.65X stereo objectives have a working distance of about 5.9 mm which will not clear the green plastic holddown rings used by IEG. The 2.65X monoscopic objective has an even smaller working distance of about 3.4 mm.

Eyeguards adapted to fit the 40.45 mm outside diameter of the 15X eyepieces were provided. They effectively cut out most of the extraneous light for four observers (T&E engineers). They do, however, restrict the useable field of view of one of the observers by about 32 percent (linear). The eyeguards keep him from getting close enough to the exit pupils.

The eyeguards fit snugly on the eyepieces, and the 15X eyepieces are 3.5 times heavier (158 grams) than the usual 10X eyepieces. These two facts can cause the unwary, when intending to remove the eyeguard, to unexpectedly lift the eyepiece out of the eyepiece tube and then lose their grip so that they drop it.

The performance of the focusing mechanism originally provided on the AIL 1540 light tables has been poor with the 60X Zoom 240 optics used in the past. The smaller depth of field of these new 120X optics makes it prohibitively difficult to use them on light tables with the original focus mechanism. However, performance is judged to be satisfactory on tables which have been modified by changing the focus mechanism gear ratio.

5.3 Operational Evaluations

The two operating components that evaluated the eyepieces, stereo objectives, and monoscopic objective reported that most PIs consider light table vibrations a more serious problem with the increased magnification of 120X. One of the components found that this serious problem can be reduced from harmful to "slightly bothersome" at worst with the ESD plate and clamp vibration attenuator.*

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* Described in a limited distribution Memorandum for the Record "Temporary Vibration Fix for the AIL 1540 Light Table," NPIC/TSG/ESD/TEB-124/71, dated 31 August 1971.

The twenty PIs from one operating component and five PIs from the other component unanimously reported that the 2.65X stereo objectives with the 15X eyepieces provide a magnification capability on their light tables that is sufficient. One PI reported that one piece of ground order of battle equipment was readily identified that was not identifiable on the old Zoom 240 system. Many PIs felt that their need for the [redacted] High Power Stereoviewer and the [redacted] M-5 would be reduced or eliminated. This does not apply to PIs engaged in third-phase, detailed photointerpretation. 25X1 25X1

Use of the mono objective is seriously hampered by the need to remove the 2.65X stereo objectives before the mono objective can be focused according to both operating components. They conclude that the prototype monoscopic objective does not add to the 120X capability.

One operating component stated that the closeness of the stereo objectives to the imagery bars the use of all known film holddowns.

The increased field of view provided by the new eyepieces was well received by all PIs. One PI stated that he would search at 28X (minimum zoom setting) with the 120X capability rather than at 28X with his current optics. One operating component commented on the human engineering aspect of the large diameter eyepieces being uncomfortable against the user's nose. This component also reported that the PI's nose hit the edges of the large diameter eyepieces.

More extensive comments made by one of the components are:

- The illumination from [redacted] 1540 and [redacted] light tables is adequate for the 120X system except for the viewing ports. 25X1 25X1

- The user must crane his neck to look through the viewing ports.

- While the two-dot version of the viewing port eased the parallax problem, the majority of their PIs believe that stereo fusion can be achieved faster without using the viewing ports.

- Use of the viewing ports eliminates guesswork in finding the same imagery area in both rhomboids.

o Some of their PIs felt that more light was needed through the viewing ports.

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